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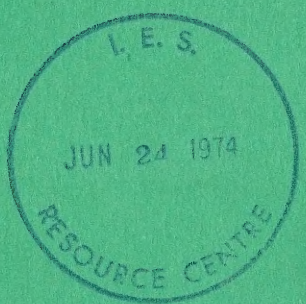
A Study of the Waste Characteristics of Fish Processing Plants



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A STUDY OF THE WASTE CHARACTERISTICS OF FISH PROCESSING PLANTS LOCATED IN THE MARITIME REGION

by

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Environmental Protection Service

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ABSTRACT

Fish processing plants located in Shippegan, Caraquet, and Lameque region of the Province of New Brunswick, were chosen for this study. This report contains the results of a study to determine the waste characteristics of the fish processing industry. The effluent sampling and analyses program characterises waste from 8 plants processing groundfish, shellfish, combined groundfish and shellfish, herring, and fish meal. Waste flows and plant production figures were incorporated with the waste parameter BOD_5, suspended solids and oil content for each type of processing plant.

Key Words: Characterization, fish, fish meal, fish processing plants, groundfish, herring, Maritime Region, production, processing, shellfish, variation, wastes, water use.

RÉSUMÉ

Pour cette étude, on a choisi des usines de traitement du poisson situées dans les régions de Shippegan, de Caraquet et de Lamèque (N.-B.). Le présent rapport renferme les résultats d'une étude destinée à déterminer les caractéristiques propres aux déchets de l'industrie de traitement du poisson. Le programme d'analyse et d'échantillonnage des effluents caractérise les déchets provenant de huit usines traitant des poissons de fond ou des mollusques et des crustacés (ou les deux à la fois), de même que du hareng, et des farines de poisson. Les chiffres relatifs à l'écoulement des déchets et à la production des usines ont été incorporés au paramètre BOD_5 et aux données concernant les solides en suspension et la teneur en pétrole pour chaque type d'usine de traitement.

Mots-clés: caractérisation, poisson, farine de poisson, usines de traitement du poisson, poissons de fond, hareng, région des Maritimes, production, traitement, mollusques et crustacés, variation, déchets, utilisation des eaux

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CONCLUSIONS

Based on data collected from a waste survey of fish processing plants located in the Maritime Region, the following conclusions can be made:

1. The waste characteristics for groundfish, shellfish, combined shellfish and groundfish, herring and fish meal processing plants were determined and are those reported in Tables 5 and 6 which are found on pages 39 and 40 of this report. The waste characteristics determined are subject to variation as indicated in Table 7, page 42.

2. Although considerable variation existed in the data, the BOD_5 of wastes can be approximated as follows:

groundfish and shellfish wastes,

$$BOD_5 = 0.35\ COD$$

herring wastes,

$$BOD_5 = 0.68\ COD - 186$$

These relationships are intended to be used only as a guide.

3. For the plants studied, the rate at which water is used by any particular process is relatively constant regardless of the quantity of fish being processed.

RECOMMENDATIONS

1. It is recommended that a study be initiated to determine the effects of fish processing waste on both the ecology and water chemistry of the receiving waters.

2. Additional waste characteristics should also be determined for the sardine processing plants, and those plants which produce such products as fishsticks, breaded fillets, etc.

CHAPTER 1

INTRODUCTION

Prior to the design of a treatment system for a particular industry, it is essential that the characteristics of the wastes from that industry be known. The determination of waste characteristics can be accomplished either by monitoring the waste stream of an industry and performing the associated analyses, or they can be obtained from values reported in the literature. Fortunately, for many of the industrial wastes encountered, considerable waste characteristic data is available in the literature. Very little information is available, however, on the waste characteristics of the fish processing industry.

1.1 Purpose and Scope

Since data on waste characteristics of fish processing plants is limited, this study was undertaken to determine the characteristics of the waste being discharge from fish processing plants.

The study was limited to an investigation of those fish processing plants located in the Maritime Region (New Brunswick, Prince Edward Island and Nova Scotia) and was to determine the waste characteristics BOD_5, SS, Oil, and water usage. All waste characteristics were to be based on plant production figures.

CHAPTER 2

PLANT AND PROCESS SELECTION

Fish processing plants located in the Shippegan, Caraquet, Lameque area of north-eastern New Brunswick were selected as representative plants from which data were obtained to form the basis of this study. The individual operations investigated included groundfish processing, shellfish processing, combined groundfish and shellfish operations, herring processing and fish meal production.

2.1 Plant Selection

Due to time limitations of the study it was essential that a study area be chosen which represented not only a wide diversity in fish processing but also represented a significant portion of the total fish landings of the Maritime Region. Several areas in the Region were under consideration, but the one which seemed best to suit the limiting conditions was the Shippegan, Caraquet, Lameque region of New Brunswick.

Shippegan, Caraquet and Lameque are located in north-eastern New Brunswick (Figure 1) and are communities in which the fishing industry is of considerable economic importance. The 18 fish processing plants located in the area produce fish products from herring, cod, ocean perch (redfish), flounder, crab, lobster and shrimp (Table 1). Since these species predominate in Region landings, the chosen study area seemed to be representative of the entire Maritime Region. The attractiveness of this area as one in which to base the study is indicated, not only by the variety of processes found there, but also by the quantity of fish landed.

Figures from the Economics Branch of the Departments of Fisheries revealed that in 1970 the landings of cod, ocean perch, flounder, herring, shrimp, lobster and crab in the Maritime Region was 994,577,700 pounds, or 88% of the landings of all species in the Region. Of this 994,577,700 pounds, 267,420,000 pounds, or, 27% of the landings of these species in the Region were contributed by the Shippegan, Caraquet, Lameque area (Table 2). Also, when comparing

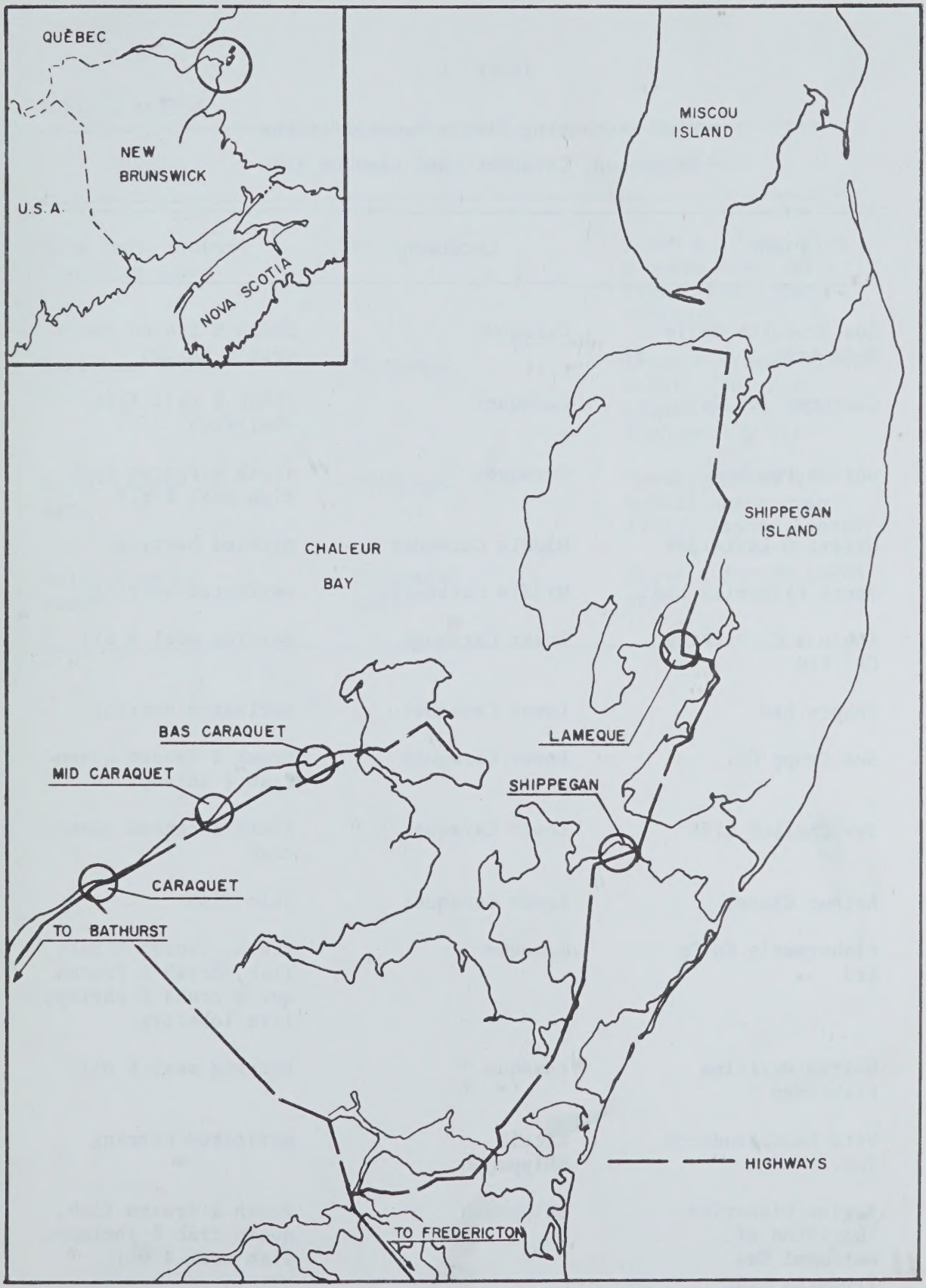

FIG. 1 LOCATION OF STUDY AREA

TABLE 1

Fish Processing Plants Located in the Shippegan, Caraquet, and Lameque Area

Plant	Location	Product
Les Produits Belle Baie Ltée	Caraquet	fresh & frozen queen crab & shrimp
Caraquet Ice Co.	Caraquet	fresh & salt fish shellfish
Gorton Pew Ltd.	Caraquet	fresh & frozen fish, fish meal & oil
Ernest G Lanteigne	Middle Caraquet	pickled herring
Booth Fisheries Ltd	Middle Caraquet	marinated herring
Anglo B.C. Packing Co. Ltd	Lower Caraquet	herring meal & oil
Seapro Ltd	Lower Caraquet	marinated herring
Sea Cropp Co.	Lower Caraquet	fresh & frozen queen crab & shrimp
Bay Chaleur Ltée	Lower Caraquet	fresh & canned queen crab
Arthur Gionet	Lower Caraquet	salt fish
Fishermen's Co-Op Ltd	Lameque	fresh, frozen & salt fish, fresh & frozen queen crabs & shrimp, live lobsters
United Maritime Fishermen	Lameque	herring meal & oil
Vita Food Products Inc.	Little Shippegan	marinated herring
Eagles Fisheries (Division of National Sea Products Ltd.)	Shippegan	fresh & frozen fish, queen crab & shrimps, fish meal & oil

Table 1 cont'd

Plant	Location	Product
Swim Bros. Fisheries Ltd	Shippegan	fresh & frozen fish & queen crab, salt fish, live & canned lobsters
Robichaud & Co. Ltd.	Shippegan	fresh & frozen fish, fresh, frozen & canned queen crab, fish meal & oil
W. S. Loggie Co. Ltd.	Shippegan	fresh, frozen & canned queen crab, live & canned lobsters
Gully Fish & Foods	Shippegan Gully	fresh & frozen queen crab

TABLE 2

Landings in Maritime Region and

Shippegan, Caraquet, and Lameque

for 1970

Species	Landings (lbs)	
	Maritime Region	Ship. Car. Lam.
Herring	579,188,600	195,497,000
Cod	142,633,000	17,631,000
Ocean Perch	88,927,400	29,100,000
Flatfish	88,425,500	12,386,000
Lobster	30,665,300	959,000
Crab	11,565,500	10,771,000
Shrimp	3,172,400	1,076,000
Sub Total (S.T.)	994,577,700	267,420,000
Other Species	131,836,000	5,345,000
Grant Total (G.T.)	1,076,413,700	272,765,000
$\frac{\text{S.T.}}{\text{G.T.}}$	0.92	0.98
$\frac{\text{Ship.Car.Lam. S.T.}}{\text{Marit. Reg. S. T.}}$	0.27	

landed values of New Brunswick alone, the species caught in Shippegan, Caraquet and Lameque, represent 66% of the total landings of that province (Table 3).

The significance of these figures is that the plants located in the study area represent only 4% of the total number of fish processing plants found in the Maritime Region, and yet they contribute 27% of total Maritime landings.

Therefore, since the fish processing industry in Shippegan, Caraquet, and Lameque was representative of the species being processed in the Maritime Region, and since this area produced a significant protion of the total production of the Region, the area was chosen as a base from which data was obtained for this study.

2.2 Process Descriptions

The processes which characterize the fish processing industry in Shippegan, Caraquet, and Lameque can be divided into the following five major groups:

Groundfish processing
Shellfish processing
Combined processing
Herring processing
Fish Meal and Fish Oil processing

Each group has a unique production process and consequently unique waste characteristics of the resulting effluents. Variations in processing procedures are found from plant to plant, but the major features of each type of production is quite consistant and is discussed below.

2.2.1 Groundfish Processing

Cod, ocean perch (redfish), and flounder are the species of fish referred to as groundfish - all three species being processed in somewhat the same manner. The fish, after being gutted at sea,

TABLE 3

Landings in New Brunswick and

Shippegan, Caraquet, and Lameque

for 1970

Species	Landings (lbs)	
	N.B.	Ship.Car. Lam.
Herring	319,526,400	195,497,000
Cod	20,749,300	17,631,000
Ocean Perch	30,189,100	29,100,000
Flatfish	15,084,200	12,386,000
Lobster	6,152,100	959,000
Crab	11,056,300	10,771,000
Shrimp	1,391,000	1,076,000
Sub Total (S.T.)	404,148,400	267,420,000
Other Species	34,234,800	5,345,000
Grant Total (G.T.)	438,383,200	272,765,000
S.T. / G.T.	0.92	0.98

Ship.Car.Lam. S.T. / N. B. S.T. 0.66

2.2.1 cont'd

-------- are delivered to the fish processing plant either by truck or some type of conveyor system. Upon arriving at the plant the fish are then placed in holding bins and, in order to minimize biological degradation, packed in ice. From the holding bins the fish are then flumed to the filleting tables where fillets are sliced off both sides of the fish. The portion of the fish remaining after removal of the fillets is termed offal and represents approximately 70% of the weight of the fish. The offal is flumed from the filleting tables to a receiving bin or hopper usually outside the plant and then trucked or conveyed to a fish meal plant for further processing into fish meal and fish oil.

Cod and flounder require no pretreatment prior to filleting, but the scales must be removed from ocean perch before they can be filleted. The descaling of ocean perch is accomplished in a revolving cylindrical screen which removes the scales by the abrasive action of the fish rubbing against themselves.

After filleting, the cod and flounder fillets have skins removed usually by automatic skinning machines following which they are flumed to candling table for visual inspection. The fillets of flounder and cod are candled (observed on a light table) in order to remove any remaining bones or defective meat. In addition, a nematode is sometimes found in cod, which is removed during the candling operation prior to further processing. Ocean perch require neither skinning nor candling, but go directly from filleting to further processing.

Once the fillets have been skinned and candled they are ready for final processing prior to being sent, either fresh or frozen, to the consumer market. If the fillets are sold fresh, the freshness is preserved by dipping the fillets in a brine or phosphate dip immediately after candling. If the fillets are sold frozen, a number of packaging procedures are used. If the product is intended for household use, the fillets are weighed, placed in appropriate packaging, frozen and stored until eventual release to the consumer market. If the fillets are intended for commercial sale,

they are either frozen in block form and sold as such or each individual fillet is frozen separately and then loosely packed in a large container prior to storage and shipment. This latter type of processing is called Individual Quick Frozen (IQF) and is popular for restaurant usage.

Some of the larger groundfish processing plants freeze the cuttings from the trimming tables in large blocks and then send these blocks to other plants in the Region for processing into fish sticks.

A great deal of water is used in the fluming of fish between various sections of a plant, and the associated water usage varies between individual plants. A combination of salt water and fresh water is used in the groundfish processing industry - salt water is generally used in the fluming of raw fish and offal, while fresh water is used by the skinning machines and in the fluming of cut fillets.

Wastes from groundfish processing originate at the holding tanks, filleting tables, skinning machines, candling and trimming tables and from clean-up procedures. Wastes are collected through a system of flumes and floor drains and discharged into a sump. From this receiving sump the offal is removed for processing into fish oil and fish meal. Upon removal of the offal, the remaining waste is discharged directly to the ocean, sometimes through a usually ineffective screen. A process flow diagram for the groundfish processing industry is found in Figure 2.

2.2.2 Shellfish Processing

Of the crab, lobster and shrimp processed in the Shippegan, Caraquet, and Lameque area the processing of queen crab undoubtedly predominates and is therefore discussed below. The process flow diagram for crab processing is illustrated in Figure 3.

The crab are unloaded live from the holds of the vessels into tubs and then trucked to holding rooms at the processing plant. Once in the holding rooms they are packed in ice or held in refrigerated rooms prior to processing. The first stage of crab processing is butchering which involves removal of the legs and shoulders from the main body of the crab. The main body is flumed

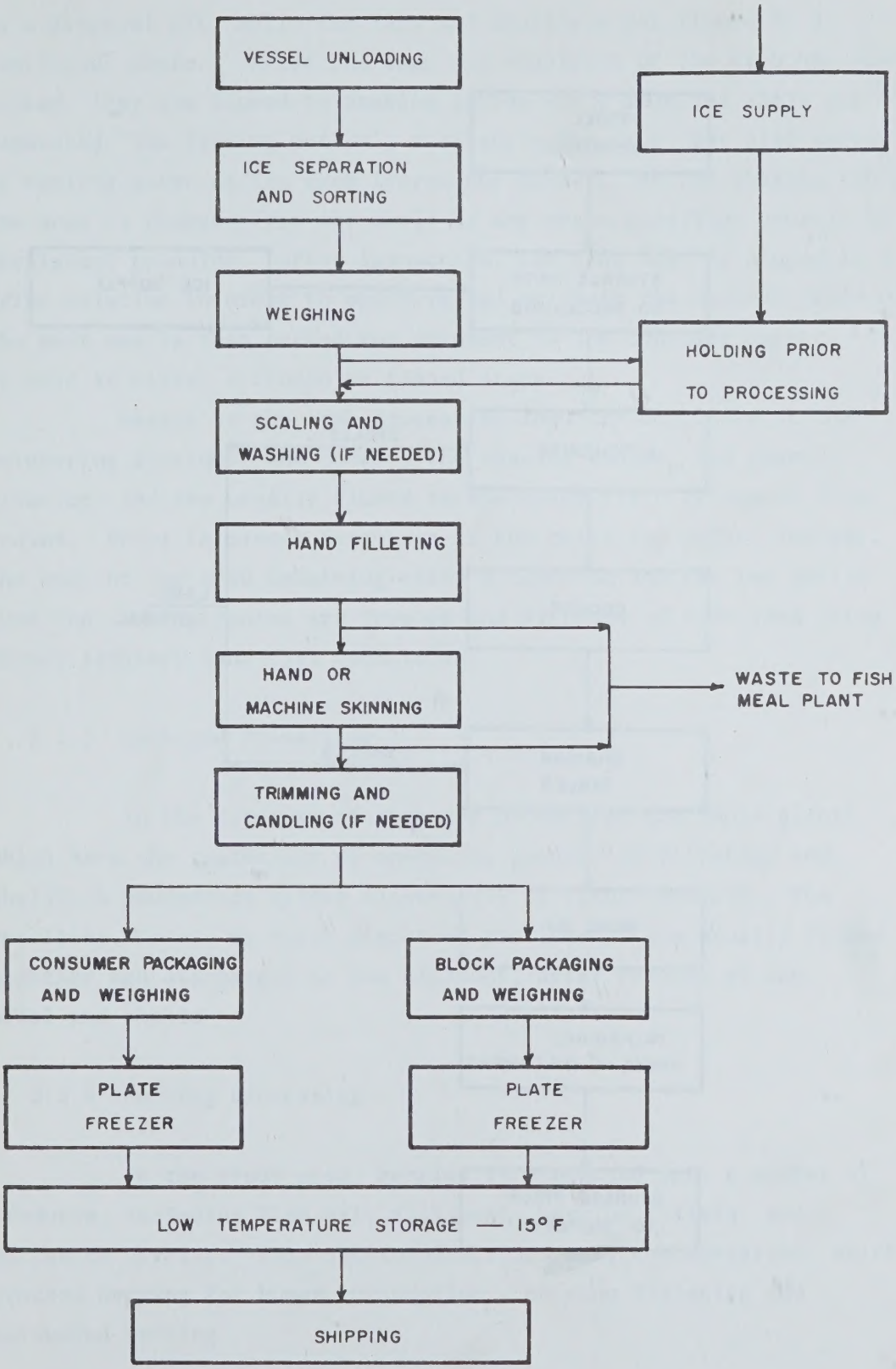

FIG. 2 PROCESS FLOW DIAGRAM
GROUNDFISH PROCESSING PLANT

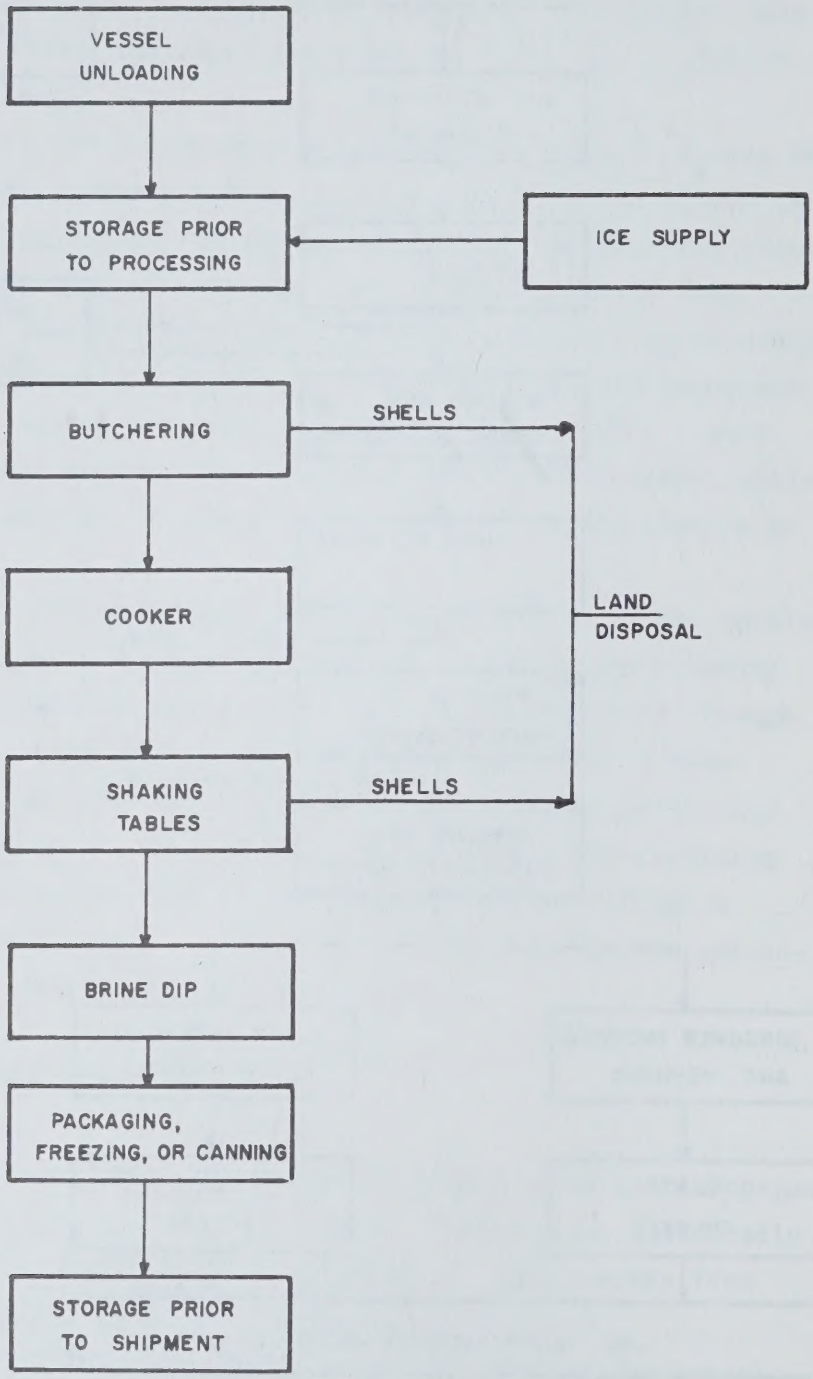

FIG. 3 PROCESS FLOW DIAGRAM
CRAB PROCESSING PLANT

to a disposal pit, while the legs and shoulders are flumed to a continuous cooker. After the legs and shoulders of the crab has been cooked, they are flumed to shaking tables where meat and shell are separated. The fluming not only transports the crab, but also serves as cooling water as the crab leaves the cooker. At the shaking tables the meat is removed from the shell by any means possible, usually by persistent pounding. After inspection, the crab meat is dipped in a brine solution in order to preserve and maintain the natural taste of the meat and is then packed for shipment to the consumer market. It is sold in either a frozen or canned state.

Wastes in the crab processing industry originate at the butchering stations, the cooker, the shaking tables, and general clean-up; and are usually flumed to discharge via a system of floor drains. Prior to direct discharge in the receiving water, however, the body of the crab remaining after butchering and the leg shells from the shaking tables are removed and disposed of over land using normal sanitary land-fill techniques.

2.2.3 Combined Processing

In the category of combined production are those plants which have the capability of operating groundfish filleting and shellfish processing either alternately or simultaneously. The resulting wastes, as those discussed previously, are usually flumed together and discharged as one effluent, after removal of the offal and shells

2.2.4 Herring Processing

In the study area, herring is processed into a number of products, including fish oil, fish meal, herring fillets, and marinated herring. This section describes only the operations which process herring for human consumption - herring filleting and marinated herring.

2.2.4.1 Herring Filleting

As with the groundfish processing plants herring are trucked to the plant and stored in holding bins, there being packed in ice. Herring are delivered to the plant round (head, tail, and viscera intact) and, in the filleting operation have the heads, tails, fins and viscera removed by automatic machines. After filleting they are prepared for consumer marketing.

Wastes in herring filleting originate from the fluming of the round herring to the splitting machines, and from the water used in the machines themselves. Offal is removed prior to final discharge of the waste water for further processing in the fish meal operation.

2.2.4.2 Marinated Herring

In the production of marinated herring, round herring is trucked to the processing plant and stored in iced or refrigerated bins. From the storage bins the herring are either flumed or conveyed to a hand or machine splitting operation where removal of head, tails, fins and viscera takes place. The resulting split fillets are then stored in barrels or vats in a solution of brine and acetic acid for a period of 5 to 9 days. After this period the solution is dumped and the fillets are introduced to a second solution of brine and acetic acid and stored at low temperature for a period of two weeks. While in this stored solution the fillets are called bismarcks. After this minimum two-week period the bismarck are dumped, skinned, and re-packed in barrels ready for distribution. The process is illustrated in Figure 4.

Wastes are produced during the splitting operation, clean-up, and acetic acid-brine dumps. The offal can be transported to fish meal plants for further processing.

With both the herring filleting and marinated herring processing, the waste is extremely colored, no doubt due to the loss of blood during the splitting operation. The coloration does not dissipate upon discharge to the receiving waters.

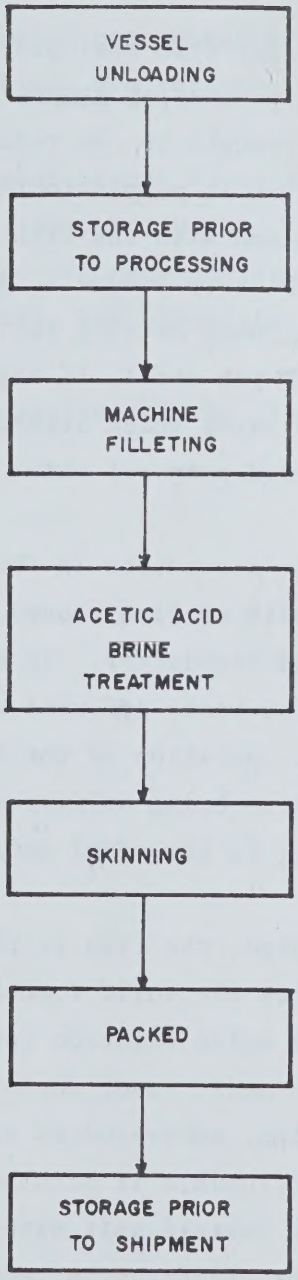

FIG. 4 PROCESS FLOW DIAGRAM
MARINATED HERRING PLANT

2.2.5 Fish Meal Processing

The raw product for fish meal processing is either a combination of offal from groundfish plants and round herring or round herring alone. Offal is brought to the reduction plant via truck or conveyor while round herring is pumped to the plant from the vessels at dock side. Water is mixed with the fish in the hold of the vessel in a 1:1 ratio. and this mixture pumped to a chain conveyor outside the reduction plant. The round herring is then coveyed into concrete holding bins together with the offal, if any, from the groundfish filleting operation. The water which separates from the herring on the chain conveyor is termed pump-out water and is discharged back to the receiving waters.

As fish begin to accumulate in the holding bins, the weight of the resulting pile of fish causes a viscous substance to ooze from the pile, called bloodwater. In some installations this bloodwater is discharged as waste effluent while in others it is introduced into the first operation of the fish meal operation, the continuous cooker. Also being delivered to the cooker, by means of a screw conveyor, is the offal and/or round herring from the holding bins.

After being cooked, the fish is then delivered to a screw press which separates the solid fraction of the cooked fish from the liquid fraction. The solid fraction (press cake) is then dried, ground and bagged as fish meal, ready for distribution and sale. During the drying operation, severe odors are emitted which are quite obnoxious and objectionable if scrubbers are not provided. Most plants, however, now install salt water scrubbers, called deodorizers, and are quite effective in reducing odors from the drying operation.

The liquid from the pressing operation (press liquid) is screened to remove any additional solids for introduction to the drier along with the remainder of the press cake. The press liquid itself, which consists of fish oil and stickwater, is pumped to storage tanks and the subsequently centrifuged in order to separate

the oil from the stickwater. Some plants discharge the stickwater to the receiving water, but most plants process stickwater in a triple effect evaporator which concentrates the solid fraction. The concentrated solids (solubles) are returned to the drier for further processing.

Wastes in fish meal plants which recover stickwater originate from: clean-up, pump-out water, deodorizer water, and evaporator condenser water. If recovery procedures are not used, stickwater, separator sludge, and bloodwater must be added to this list.

A process flow diagram for the fish meal industry is found in Figure 5.

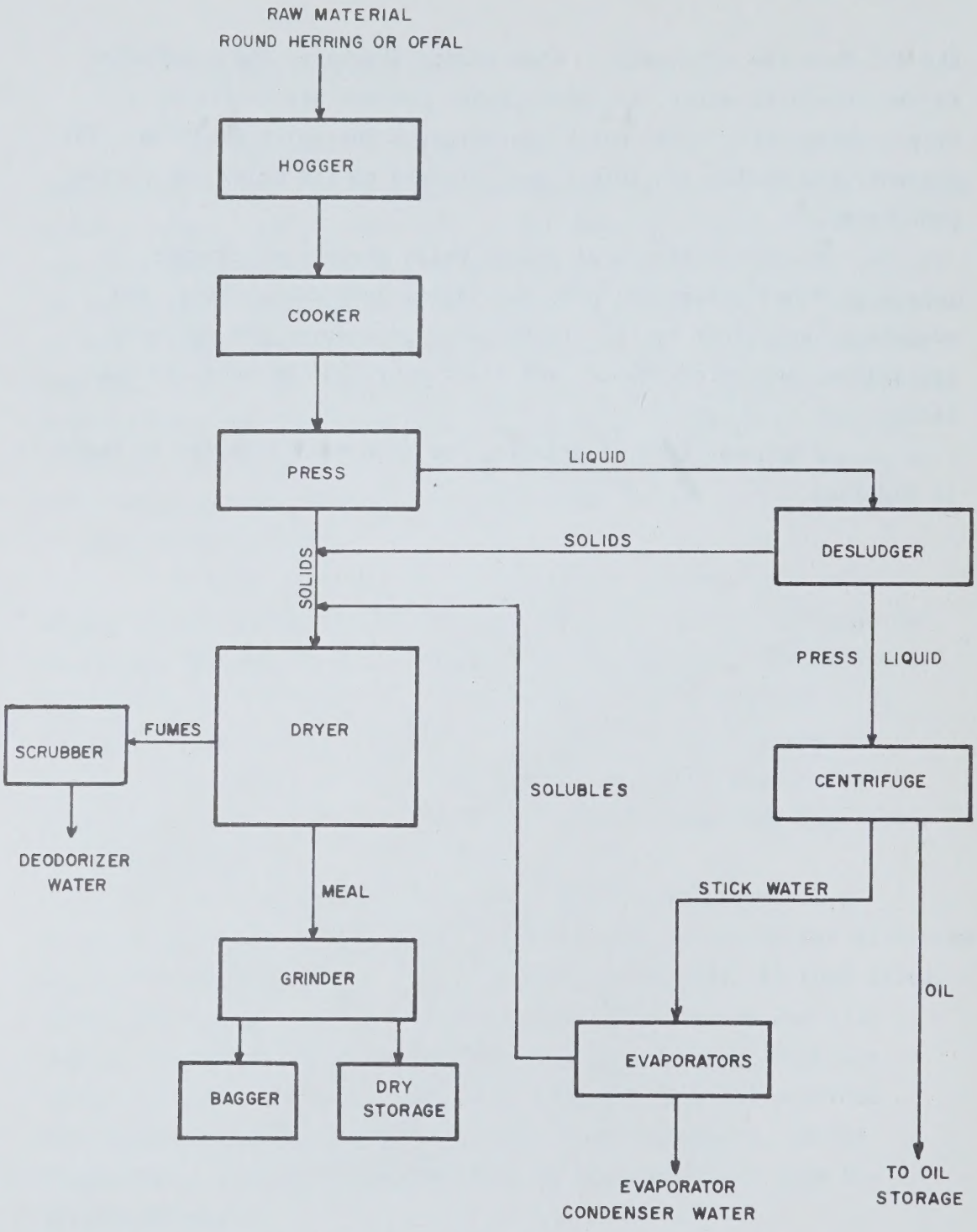

FIG. 5 PROCESS FLOW DIAGRAM
FISH MEAL PRODUCTION

CHAPTER 3

DATA COLLECTION

Samples were taken from the waste streams of several representative fish processing plants and analysed for BOD_5, COD, SS, TVS, and oil content. In addition to these waste chracteristics data was also obtained on the quantity of water used and the associated production of a plant during its observation.

3.1 Laboratory Procedures

In order that the data obtained from this study be representative, it was necessary that the waste characteristics chosen represent the overall pollutant characteristics of the waste. The overall strength of a waste can be estimated from the Biological Oxygen Demand (BOD), and Suspended Solids concentration (SS) and as such, these two characteristics were chose to describe the fish processing wastes. In addition to BOD and SS, the oil content of the waste was also measured, since some of the fish processed are characteristically oily. Ancillary waste characteristics that were measured included Chemical Oxygen Demand (COD), and Total Volatile Solids (TVS). All tests were performed according to Standard Methods (1) unless otherwise specified and were performed at the Pollution Control Laboratory at the Bedford Institute of Oceanography in Darmouth, Nova Scotia.

3.1.1 Biological Oxygen Demand (BOD)

The BOD test measures the amount of organic material in a waste that is biologically oxidizable, the amount being oxidized during a five-day period often being reported. The five-day BOD (BOD_5) was chosen for this study.

In order to prevent biological degradation of the samples during the period elapsing between sampling and analysis, the BOD samples were treated with acid immediately upon sampling. This acid pretreatment of the samples necessitated the development of a

a bacterial seed to be used in the BOD determinations. This seed was developed in a batch unit from waste obtained from the Forty Fathoms Division of National Sea Products, Halifax, Nova Scotia. Seed was added to the BOD dilution water in the quantity of 2 mℓ per ℓ of dilution water. All samples were neutralized prior to their incubation at 20°C.

In addition to neutralization, the samples were analyzed for any residual chlorine content prior to the performance of the BOD procedure. Residual chlorine analysis was necessary since chlorine is added to the fish plant process water in order to deter the growth of harmful bacteria. Residual chlorine determinations were performed on the BOD samples whenever a plant was visited for the first time. If no residual chlorine was found, it was assumed that no residual would be found for the duration of that plant visit and no further residual determinations were made on subsequent samples. If, however, a chlorine residual was measured, the residual test was performed on every BOD sample and the necessary pretreatment as outlined in Standard Methods performed. All samples were blended in a Waring Blender prior to analysis.

3.1.2 Suspended Solids (SS)

The quantity of solids in the waste (SS), was determined by filtering 100 mls of the sample through a millipore filter and determining the constant weight after drying. If the concentration of solids in a sample was so high that filtering was inhibited, the sample was diluted prior to filtering. In order to guarantee representative solid samples, all samples were blended in a Waring Blender prior to the determination of SS.

3.1.3 Oil Content

The determination of the oil content of the waste was accomplished through a test previsouly used by the Fisheries Research Board in Vancouver (2). Essentially, the test involves treatment of a waste sample with sulphuric acid in a Babcock flask and, after cooling, centrifuging at 1000 rpm. The sample is then

re-heated in a water bath and once again centrifuged. The oil content of the waste (in percent) is read directly from the calibrations on the neck of the Babcock flask. The results were converted to units of mg/ℓ by reporting the concentration as H_2O.

3.1.4 Total Volatile Solids (TVS)

The concentration of TVS in a waste sample was determined by evaporating 50 mls of the sample in an evaporating dish, drying to constant weight, and then measuring the weight, and then measuring the weight of the remaining solids after ignition.

3.1.5 Chemical Oxygen Demand (COD)

The COD measures the quantity of organics in a waste water which are chemically oxidizable. For many industrial waste correlations can be found between COD and BOD, and, in an attempt to find such a correlation for fish processing wastes, COD determinations were included in the study.

3.2 Field Procedures

The method of sampling used ensured that representative waste samples were obtained through the use of proper sampling techniques and sample preparation. Both waste flow and production figures were obtained so that these variables could be used in the final determination of the waste characteristics.

3.2.1 Collection of Samples

Considerable variation can exist in the waste characteristics of an industrial effluent due to differences in day to day plant processing procedures. Consequently, in any industrial waste survey, it is essential that these variations be taken into consideration in the determination of waste characteristics. To therefore ensure the measurement of waste variations so that representative waste characteristics could be obtained, each fish processing plant visited

was sampled for a period of 4-5 days. Sampling commenced in the early morning and continued until late afternoon with composite samples being taken every 30 minutes. If, due to a shortage of fish, the fish plant did not operate for a complete day, the duration of sampling was coincident with the duration of production. Also to ensure the reflection of process variation in waste characteristics all sample sizes were taken in proportion to the waste flow existing at any particular sampling time. All samples were taken prior to the discharge of the waste through any screens.

Generally, samples were composited in two sets daily, one set of composite samples for the morning operation, and one for the afternoon. Every set of composite samples included 3 containers - one for BOD_5 analysis, one for SS determination, and the other for measurement of waste oil content. The BOD_5 and SS samples were placed in plastic containers, while oil samples were put in a glass container. In order to prevent or minimize the biological degradation of the waste during the period between sampling and analysis, the BOD_5 and oil samples were treated with acid so that the resulting pH was in the order of 1 or 1.5. The SS samples were not treated with acid, however, in the eventuality that the developed pH would alter the solubility of dissolved proteins, causing them to precipitate and thereby influence the SS concentration.

Each set of samples was placed in a cooler and the contents packed with ice prior to their shipment to the laboratory in Dartmouth, Nova Scotia. If samples had to be stored overnight or over a week end, they were frozen during storage.

3.2.2 Measurement of Waste Flows

An essential part of any waste characteristic study is the determination of waste flows. In this study, waste flows were determined using one of two methods. In the plants which had metered water supplies, the quantity of water used was read directly from the meter. Since most plants use both fresh and salt water in their processing, and since both flows were metered

in those plants equipped with meters, data could be obtained on the usage of both types of water.

For the plants not equipped with meters, the waste flow was measured using either the bucket-stopwatch method, or the floating chip method. In these particular instances no differentiation could be made between salt and fresh water usage, and the quantities of water used were reported as "combined fresh and salt".

3.2.3 Determination of Plant Production

In order to base the waste chracteristics on plant production, such data had to be obtained. The production figures both on a landed and produced basis, were readily available from plant personnel of most of the plants visited.

CHAPTER 4

RESULTS

The results from laboratory analyses on the collected samples were incorporated with waste flow data and plant production figures in order to determine the waste characteristics of the effluents of the fish processing industry. The waste characteristics for any particular process was reported in terms of lbs per 1000 lb product (landed and produced), and were calculated for wastes from the groundfish, shellfish, combined, herring, and fish meal processes.

4.1 Analysis of Data

The raw data which resulted from the laboratory analysis of field samples is found in Appendix 1 of this report, while the analyses of this data, described below, is found in Appendix 2.

Using the laboratory analyses results and the field measurements of waste flow, the weight of BOD_5, SS, and Oil being discharged every day, was calculated by summing these discharges for both a.m. and p.m. The total weight of BOD_5, SS, and Oil being discharged per day was then correlated with plant production by dividing the weight discharge per day by (a) the landed weight of fish caught, and (b) the weight of the final product. The production based waste characteristics so obtained were expressed in units of lb per 1000 lb product (product here meaning either landed or produced). If the production figures obtained were for a period of time greater than that of the sampling duration, the production figures used in the determination of waste characteristics was reduced by assuming a rate of production which was linear with time.

The amounts of water used by a particular process during any time period of sampling was determined by calculating the gallonage from the metered or measured flow data and dividing this figure by both the landed and produced production figures. In both instances, water consumption was reported in units of Imp. gal per 1000 lb product. To account for water not being used in the

process itself, i.e., domestic water, boiler water, losses, etc., 10% of the total flow was subtracted prior to the determination of the water consumption figures. This 10% figure was obtained from a consideration of data reported in a water supply report published in 1969 (3) which are reproduced in Table 4.

The waste and water characteristics calculated as described above were claculated for each day a plant was sampled, and the final characteristic for a process determined by averaging the results of each day's analysis.

Since only baseline data of the various processes was required, it was not felt necessary to identify the plants which were sampled. Consequently, the waste streams were identified by a number system, as shown in the Appendices.

4.2 Waste Characteristics

Waste characteristics for the fish processing industry were determined for effluents from groundfish processing, shellfish processing, combined processing, herring processing and fish meal processing. The waste characteristics for each of these processes are given below, and are summarized in Tables 5 and 6 found at the end of this chapter.

4.2.1 Groundfish Process

The groundfish operation involves the processing of cod, ocean perch (redfish), and flounder. Two different types of processes were analyzed - (a) a wet line operation characterized by the use of water to flume raw product and offal, and (b) a dry line operation which uses a system of conveyors and mechanically operated filleting tables.

4.2.1.1 Wet Line Process

The waste characteristics of the wet line groundfish process were found to be as follows:

TABLE 4

Percentage of Total Water used for

Various Purpose in Fish Processing Plants *

Purpose	Percentage of Total Intake Water
Fluming of Whole Fish, fillets and offal.	50 - 65
Fish washing, scaling, filleting and skinning.	15 - 25
Clean-up, plant, vessel, wharf, etc.	12 - 18
Fish meal plant.	2 - 4
Ice making.	1 - 3
Freshwater for Fishing Vessels.	1 - 2
Toilets and Washrooms	1 - 2
Boiler feed water, cooling water, etc.	1 - 2

* From Reference (3)

Waste Characteristic Concentrations:

Characteristic	Range of concentrations	Average concentrations
BOD_5	602 to 1205 mg/ℓ	1136 mg/ℓ
SS	148 to 965 mg/ℓ	489 mg/ℓ
Oil	.02 to .15%	.09%

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product Landed	Product Produced
BOD_5	15	44
SS	7	20
Oil	13	41

Water Consumption:

	Imp gal/1000 lb Product Landed	Produced
Combined	504	1596

Miscellaneous

$$\text{Avg.} \quad \frac{\text{lb. Produced}}{\text{lb. landed}} = 0.32$$

$$\text{Avg.} \quad \frac{BOD_5}{COD} = 0.39$$

4.2.1.2 Dry Line Process

The dry line operation visited flumed the fish from holding tanks to the mechanically operated filleting tables. Upon removal

of the fillets, the offal was discharged via a separate flume for disposal. The characteristics reported below include only data from the offal flume and the candling and skinning operation, and does not include data on the flume water from the holding tanks to the filleting tables.

Waste Characteristic Concentration Ranges:

Characteristic	Range of concentrations	Average concentration
BOD_5	100 - 1140 mg/ℓ	455 mg/ℓ
SS	30 - 232 mg/ℓ	135 mg/ℓ
Oil	0 - .05%	.01%

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product	
	Landed	Produced
BOD_5	5	7
SS	1	2
Oil	1	2

Water Consumption :

	Imp gal/1000 lb Product	
	Landed	Produced
Combined	504	1596

Miscellaneous

Avg. $\frac{\text{lb Produced}}{\text{lb Landed}} = 0.31$

Avg. $\frac{BOD_5}{COD} = 0.48$

4.2.2 Shellfish Process

The processing of lobsters, queen crab, and shrimp comprises the shellfish industry in the Shippegan, Caraquet, and Lameque area. The lobster season for that area of New Brunswick closed July 1, about one week before this survey began field operations. Consequently, due to the variable supply of lobster, survey data was obtained when production was intermittent and of variable duration.

A great deal of queen crab is processed in the area, indeed 93% of all the crab processed in the Maritime Region comes from Shippegan, Caraquet, and Lameque (See Table 2). Shrimp, on the other hand, is only processed by a few plants and represents only a small fraction of the total shellfish production for the area. No data was obtained on wastes from the shrimp processing industry.

4.2.2.1 Lobster Processing

Waste Characteristic Concentration Ranges:

Characteristics	Range of concentration	Average concentration
BOD_5	843 - 1205 mg/ℓ	1008 mg/ℓ
SS	141 - 174 mg /ℓ	164 mg/ℓ
Oil	.01 - .08%	.03 %

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product Landed	Produced
BOD_5	26	110
COD	4	18
SS	5	20

Water Consumption:

	Imp gal/1000 lb Product	
	Landed	Produced
Combined	2,613	10,745

Miscellaneous:

Avg. $\frac{\text{lb Production}}{\text{lb Landed}} = 0,27$

Avg. $\frac{BOD_5}{COD} = 0.49$

4.2.2.2 Crab Processing

Waste Characteristic Concentrations:

Characteristic	Concentration range	Average
BOD_5	320 - 1000 mg/ℓ	676 mg/ℓ
SS	135 - 661 mg/ℓ	301 mg/ℓ
Oil	.01 - .09%	.03%

Waste Characteristic Based on Production:

Characteristic	lb/1000 lb Product	
	Landed	Produced
BOD_5	40	270
SS	19	84
Oil	21	93

Water Consumption:

	gal/1000 lb Product	
	Landed	Produced
Fresh	739	3312
Salt	5447	24,567

Miscellaneous

$$\text{Avg.} \quad \frac{\text{lb Produced}}{\text{lb Landed}} = 0.22$$

$$\text{Avg.} \quad \frac{BOD_5}{COD} = 0.32$$

4.2.3 Combined Processing

The plants designated as combined are those which produce groundfish fillets and shellfish products either simultaneously or alternately.

Waste Characteristic Concentration Ranges:

Characteristic	Range of concentration	Average concentration
BOD_5	1100 - 1440 mg/ℓ	1192 mg/ℓ
SS	174 - 330 mg/ℓ	297 mg/ℓ
Oil	.02 - .1%	.05 %

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product	
	Landed	Produced
BOD_5	18	65
SS	4	14
Oil	7	23

Water Consumption:

	Imp gal/1000 lb Product	
	Landed	Produced
Fresh	179	629
Salt	1317	4607

Miscellaneous

$$\text{Avg.} \quad \frac{\text{lb Produced}}{\text{lb Landed}} = 0.29$$

$$\text{Avg.} \quad \frac{BOD_5}{COD} = 0.43$$

4.2.4 Herring Processing

The processing of herring for the household consumer market involves only two processes in the Shippegan, Caraquet, and Lameque area. The landed round herring is either filleted and sold as such, or else treated with brine and acetic acid and sold as marinated herring.

4.2.4.1 Herring Filleting

The following data was obtained at a plant which was equipped to automatically split, deheat, detail, and defin the round herring.

Waste Characteristic Concentration Ranges:

Characteristic	Range of concentration	Average concentration
BOD_5	3200 - 5800 mg/ℓ	3859 mg/ℓ
SS	1150 - 5310 mg/ℓ	3011 mg/ℓ
Oil	.02 - .3%	0.12%

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product Landed	Produced
BOD_5	22	68
SS	21	37
Oil	10	29

Water Consumption:

	Imp gal/1000 lb Product	
	Landed	Produced
Combined	599	1786

Miscellaneous

Avg. $\frac{\text{lb Produced}}{\text{lb Landed}} = 0.34$

Avg. $\frac{BOD_5}{COD} = 0.63$

4.2.4.2. Marinated Herring

As with the herring filleting operation, the marinated herring plant visited used machines to automatically split, dehead, detail and defin the round herring. Data was not obtained on the acetic acid dumps, so the characteristics reported below is representative of the processing of the herring, excluding the acetic acid-brine dumps.

Waste Characteristic Concentration Ranges:

Characteristic	Range of concentration	Average concentration
BOD	6900 - 14,000 mg/ℓ	8880 mg/ℓ
SS	1508 - 4,600 mg/ℓ	3410 mg/ℓ
Oil	.08 - .5%	0.25%

Waste Characteristics Based on Production:

Characteristic	lb/1000 lb Product	
	Landed	Produced
BOD_5	215	527
SS	85	210
Oil	83	215

Water Consumption:

	gal/1000 lb Product	
	Landed	Produced
Fresh only	2460	6179

Miscellaneous

Avg. $\frac{\text{lb Landed}}{\text{lb Produced}} = 0.41$

Avg. $\frac{BOD_5}{COD} = 0.68$

4.2.5 Fish Meal Processing

The waste streams measured in the fish meal plant visited included pumpout water, bloodwater, separator sludge, stickwater, solubles, evaporator condenser water, and deodorizer water. Unfortunately, the management of the plant was reluctant to give plant production figures, consequently, the waste characteristics obtained could not be correlated with production.

Estimates of waste flows were obtained from plant personnel, however, and are reported with the following data. It is important to note that these waste flows are only estimates. Accurate measurement of flows is not possible without measuring devices more sophisticated than those available for this study. In-line measuring devices would, no doubt, be required.

4.2.5.1 Pumpout Water

Pumpout water is that water which is used in the transport of herring from the hold of the vessel to the fish reduction plant. Plant estimates for the flow of pumpout water was 300 gpm.

Waste Characteristic Concentrations:

Characteristic	Average Concentration*
BOD_5	33,500 mg/ℓ
SS	7,955 mg/ℓ
Oil	.05%

$$\frac{BOD_5}{COD} = 0.50$$

* Based on composites of 2 days sampling

4.2.5.2 Bloodwater

The measurment of bloodwater flow is virtually impossible due to its method of release from the holding bins.

Waste Characteristic Concentration Ranges:

Characteristic	Range of concentration	Average concentration
BOD_5	190,000-315,000 mg/ℓ	245,000 mg/ℓ
SS	4,168-21,430 mg /ℓ	11,805 mg/ℓ
Oil	0.25-0.3%	0.27%

$$\frac{BOD_5}{COD} = 0.64$$

4.2.5.3 Separator Sludge

A small quantity of sludge is released intermittently from the centrifuge, which, in most plants, is recycled back into the process. The flow of separator was estimated to be 100 U.S gal/ hr.

Waste Characteristic Concentrations:

(based on 2 days samples)

BOD_5	280,000 mg/ℓ
SS	13,500 mg/ℓ
Oil	0.22 %

$$\frac{BOD_5}{COD} = 0.58$$

4.2.5.4 Stickwater

The portion of the press liquid which remains after the separation of fish oil is known as stickwater. Some installations discharge the stickwater directly into the receiving waters, but most plants reprocess the stickwater. The flow of stickwater was estimated to be 4,500 U.S. gal/hr.

Waste Characteristic Concentrations:

Characteristic	Range of concentration	Average concentration
BOD_5	46,000 -490,000 mg/ℓ	198,700 mg/ℓ
SS	7,600 - 21,500 mg/ℓ	15,500 mg/ℓ
Oil	.01- .05%	.03%

$$\frac{BOD_5}{COD} = 0.68$$

4.2.5.5 Solubles

The flow of solubles was estimated at 450 U.S. gal/hr.

Waste Characteristic Concentrations:

Characteristics	Range of Concentration	Average Concentration
BOD_5	150,000-245,000 mg/l	184,250 mg/l
SS	1,050- 85,500 mg/l	41,613 mg/l
Oil	.02- 0.2%	0.13%

$\frac{BOD_5}{COD} = 0.53$

4.2.5.6 Evaporator Condenser Water

The flow of condenser water from the triple effect evaporators was estimated to be 2,000 U.S. gpm and was found to have the following characteristics.

Waste Characteristic Concentration Ranges

Characteristics	Range of Concentration	Average Concentration
BOD_5	880-1,549 mg/l	1,132 mg/l
SS	4- 220 mg/l	58 mg/l
Oil	0-.03%	.01%

$\frac{BOD_5}{COD} = 0.55$

4.2.5.7 Deodorizer Water

The Water used to absorb odors from the drier fumes had a flow estimated at 1,400 U.S. gpm.

Waste Characteristic Concentration Ranges

Characteristic	Range of Concentration	Average Concentration
BOD_5	450-1,349 mg/l	875 mg/l
SS	12- 275 mg/l	126 mg/l
Oil	0-.01%	0.0%

$\frac{BOD_5}{COD} = 0.34$

TABLE 5

Summary of Waste Characteristics

Groundfish, Shellfish, Combined, and Herring Processing Plants

Process	lb BOD/1000 lb		lb SS/1000 lb		lb Oil/1000 lb		Gallons H_2O/1000 lb			
							Fresh		Salt	
	land	prod	land	prod	land	prod	land	prod	land	prod
Groundfish filleting (wet line)	15	44	7	20	13	41	159	485	1,324	4,187
Groundfish filleting (dry line)	5	7	1	2	1	2	504 (combined fresh and salt)	1,596	-	-
Groundfish filleting and crab	18	65	4	14	7	23	179	626	1,317	4,607
Shellfish Lobster	26	110	4	18	5	20	2,613 (combined fresh and salt)	10,745	-	-
Shellfish Crab	40	270	19	84	21	93	739	3,312	5,447	24,567
Herring Filleting	22	68	21	37	10	29	599 (combined fresh and salt)	1,786		
Herring Marinated	215	527	85	210	83	215	2,460	6,179	0	0

TABLE 6

Summary of Waste Characteristics

Fish Meal Process

Waste Stream	Average Concentrations		
	BOD_5 (mg/ℓ)	SS (mg/ℓ)	Oil %
Pumpout Water	33,500	7,955	.05
Bloodwater	245,000	11,805	.27
Separator Sludge	280,000	13,500	.22
Stickwater	198,700	15,500	.03
Solubles	184,250	41,163	.13
Evaporator Condenser Water	1,132	58	.01
Deodorizer Water	875	126	0

CHAPTER 5

DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

5.1 Data Variation

Considerable scatter exists in the data of average waste characteristics as is evidenced by comparing means and standard deviations of the processes listed in Table 7. The wide variation in data is not peculiar to any one waste characteristic, but applies to all, including water consumption. In addition to variations in processing procedures, the scatter in the data is, no doubt, also influenced by one of, or a combination of, the following factors.

1. Waste deterioration during the time interval between sampling and laboratory analysis. Although proper procedures were taken to preserve all samples during their shipment, it is quite possible that the waste could deteriorate, particularly if it were stored for extended periods of time. Shipment of samples from the field to the laboratory was sometimes unreliable and presented operational problems.

2. Nitrification. Since fish processing wastes have a relatively high protein content, it is possible that nitrification could occur in the BOD bottle prior to 5 days.

3. Fish quality. Depending upon the grade of the fish when delivered to the plant or the length of time the fish is stored prior to processing, the amount of fish discarded during candling will vary thereby influencing waste characteristics. The quality of the offal will also similarly influence the waste characteristics of the water used for fluming purposes.

The variations existing in the data were particularly evident when comparing average BOD:COD ratios and their corresponding stan ard deviations (see Table 8). Greatest variation from the mean BOD:COD was found with the groundfish and shellfish data. Indeed, the scatter of these data was so great that, at the 95% confidence level, no significant difference existed between the BOD: COD ratios of groundfish and shellfish. By comparison, however, the BOD:COD data for herring processing indicated much less scatter than

TABLE 7

Variations in Waste Characteristics of

Groundfish, Shellfish, and Herring Processing Plants

Process	lb BOD_5/1000 lb		lb SS/1000 lb		lb Oil/1000 lb		Gallons H_2O/1000 #			
							Fresh		Salt	
	Land	Stnd Dev	Land	Stnd Dev	Land	Stnd Dev	Land	Stnd Dev	Land	Stnd Dev
Groundfish Filleting (dry line)	5	3	1	0.1	1	0.5	504	224	-	-
							Combined fresh and salt			
Groundfish Filleting and Crab	18	5	4	1	7	5	179	24	1317	178
Shellfish Lobster	26	2	4	0.6	5	5	2613	248	-	-
							Combined fresh and salt			
Shellfish Crab	40	16	19	5	21		739	149	5447	965
Herring Filleting	22	7	21	15	10	4	599	138		
							Combined fresh and salt			
Herring Marinated	215	59	85	14	83	70	2460	290	-	-

TABLE 8

Average BOD_5:COD Ratios for

Shellfish, Groundfish, and Herring Processing Wastes

Process	Average BOD_5/COD	Standard Deviation
Groundfish	0.46	0.24
Shellfish	0.37	0.13
Herring	0.66	0.10

that of the groundfish and shellfish. The less scatter of the herring data can be explained by considering the manner in which the herring is processed. Both the herring filleting and marinated herring processes studie employed automatic equipment to remove the head, tail, fins, and viscera from the round herring. Consequently, through the use of automated equipment, the fish are handled in a rather consistent manner, thereby keeping process variations to a minimum. These minimum process variations in the herring operation were therefore reflected in less data scatter than that evidenced with groundfish and shellfish.

The lesser amount of data scatter for the herring process would also seem to indicate that the precautions taken to preserve the samples in the time elapsed between collection and analysis were adequate. Consequently the variations in the groundfish and shellfish data would appear to be reflective of variations in processing procedures and fish quantity rather than sample handling techniques.

In an attempt to relate BOD_5 to COD for the groundfish and shellfish processes, the scatter of these data made the usual application of the least squares method invalid. When applying the method of least squares to the data a positive intercept of BOD_5 was obtained. Since it is theoretically impossible for a positive value of BOD_5 to exist with a corresponding zero value of COD, another method of data analysis was chosen. The method of least squares was then once again applied to the data, but by forcing the curve through the origin. Only one relationship was obtained for both the shellfish and groundfish data, since the analysis of BOD:COD ratios indicated that, at the 95% level of confidence, no significant difference between the two averages. The relationship between BOD_5 and COD for groundfish and shellfish processing wastes using the method of least squares as described above, resulted in the following relationship (see Figure 6 - note, in order to preserve clarity, not all data points have been plotted)

$$BOD_5 = 0.35\ COD$$

The relationship of BOD_5 to COD for the herring data is also shown in Figure 6. Because the herring data exhibited

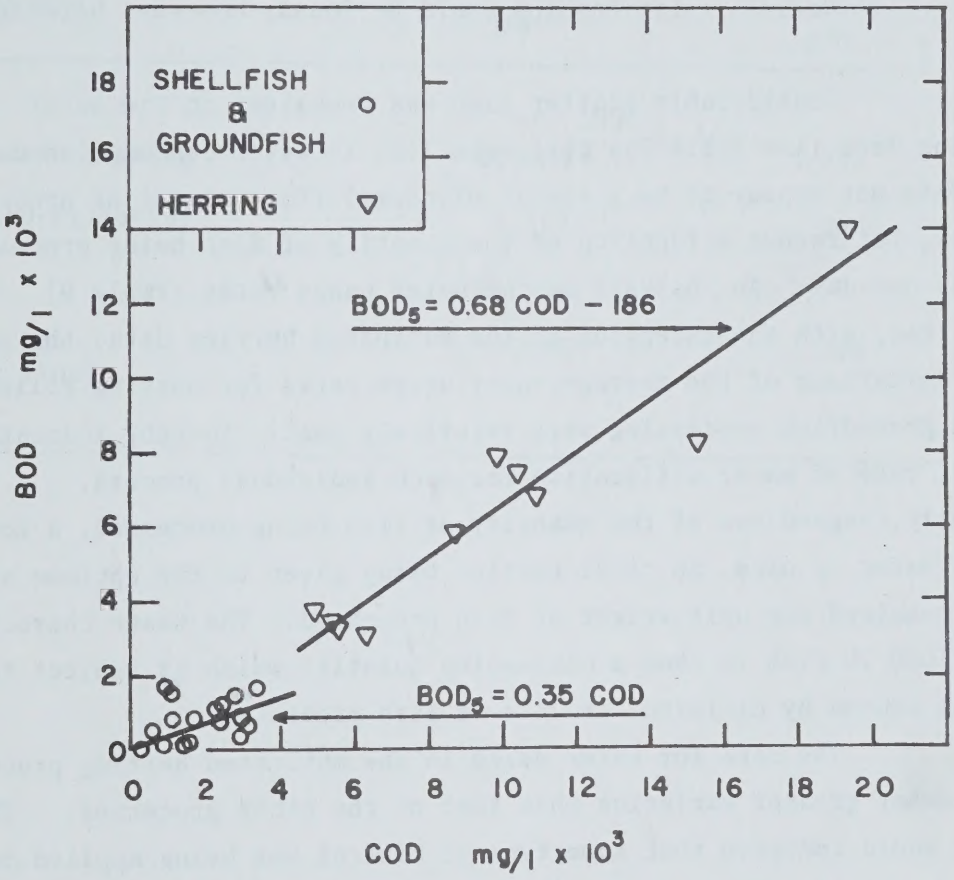

FIG. 6 RELATIONSHIP BETWEEN BOD_5 & COD FOR GROUNDFISH, SHELLFISH, & HERRING PROCESSING PLANTS

less variation than that of the groundfish and shellfish data, the method of least squares could be used in the normal manner, i.e., forcing through the origin was not necessary. The BOD_5 for the herring processing (filleting and marinated) can be described by

$$BOD_5 = 0.68 \ COD - 186$$

By setting $BOD_5 = 0$ in this question, the non-biodegradable portion of the herring waste was found to have a COD of 274 mg/1.

No such relationships could be found, however, between BOD_5 and TVS.

Considerable scatter also was prevalent in the water consumption data (see Table 7). The variations in water consumption data, however does not appear to be a result of normal fluctuations of processing procedures, but rather a function of the quantity of fish being processed during any one day. An analysis of the water usage rates (Table 9) revealed that, with the exception of the marinated herring data, the standard deviations of the average water usage rates for herring filleting crab, and groundfish processing were relatively small, thereby indicating a constant rate of water utilization for each individual process. Consequently, regardless of the quantity of fish being processed, a constant amount of water is used, no consideration being given to the optimum amount of water required per unit weight of fish processed. The waste characteristic gals H_2O/1000 lb fish is thus a misleading quantity which is subject to variations caused by different amounts of fish processed.

The data for water usage in the marinated herring process has a somewhat greater variation than that of the other processes. This variation would indicate that some type of control was being applied to water use but, upon analyzing the data from the marinated herring process itself (Table 10), it was observed that variations in water usage was not at all related to production quantities.

Consequently, an indiscriminant use of water exists in the fish processing plants which were studied.

TABLE 9

Average Water Usage of

Fish Processing Plants.

Process	Avg. Rate gph	Standard Deviation gph
Marinated Herring	22,200	5,730
Herring Filleting	5,452	265
Crab	16,354	1,000
Groundfish (Dry line)	5,684	284

TABLE 10

Water Usage and Landed Production

for Marinated Herring

Day	Water Usage (gph)	Landed Production (lbs)
1 a.m.	20,712	45,000
1 p.m.	21,734	
2	23,394	97,660
3	30,551	38,800
4	14,601	76,100

5.2 General Disucssion

As far as potential pollution sources are concerned, the effluents from the fish processing plants studied (excluding those from the fish meal operation) fall into several categories. The effluent with the highest pollutant load (based on lb BOD_5 per 1000 lb product) is that of the marinated herring process, having a BOD waste characteristic of 215 lb BOD_5 per 1000 lb landed weight. Following marinated herring can be grouped the shellfish processing wastes (26 to 40 lb BOD_5/1000 lb product), and these followed by the filleting operations (5 to 22 lb BOD/1000 lb product).

However, the use of the waste characteristics determined by this study as the sole criteria on which to base the effects of fish processing wastes on the receiving waters may be the wrong approach to the problem, in that additional field data may have to be considered. The value of additional data is exemplified by the field observation that, at almost every discharge of fish processing plant effluent, the receiving water abound with fish. Fish of various species can be seen teeming around the effluent discharges seemingly thriving on the waste being discharged. Also observed were swarms of sea gulls which would pick clean the meat from any offal that had been discharged on the shoreline leaving only the skeleton behind. Consequently, the discharge of these wastes may be contributing to the productivity of the fish species. The impact of the wastes on the productivity of this fish species should therefore be investigated both from an ecological and water chemistry standpoint prior to the determination of their impact on the receiving waters.

Although production figures were not available for the fish meal plant studied, it is apparent from the data that wastes from this industry constitute a high pollutant load on any receiving water. The recycling of such intermediate products as bloodwater, separator sludge, stickwater, etc., should be encouraged in order to attain minimum waste pollutant concentrations.

The waste from the triple effect evaporators and drier deodorizers are also an area of concern since they discharge large quantities of water (2000, and 1400 U.S. gpm respectively) with relatively high BOD_5 (1130, and 900 mg/ℓ respectively).

Due to the variability in the data, the BOD_5-COD relationships that were determined are to be considered only approximate and are intended to be used only as a guide in future laboratory determinations.

5.3 Conclusions

Based on data collected from a waste survey of fish processing plants located in the Maritime Region, the following conclusions can be made:

1. The waste characteristics for groundfish, shellfish, combined shellfish and groundfish, herring and fish meal processing plants were determined and are those reported in Tables 5 and 6 which are found on pages 39 and 40 of this report. The waste characteristics determined are subject to variations as indicated in Table 7, page 41.

2. Although considerable variation existed in the data, the BOD_5 of wastes can be approximated as follows:

groundfish and shellfish wastes,

$$BOD_5 = 0.35\ COD$$

herring wastes,

$$BOD_5 = 0.68\ COD - 186$$

These relationships are intended to be used only as a guide.

3. For the plants studied, the rate at which water is used by any particular process is relatively constant regardless of the quantity of fish being processed.

5.4 Recommendations

1. It is recommended that a study be initiated to determine the effects of fish processing waste on both the ecology and water chemistry of the receiving waters.

2. Additional waste characteristics should also be determined for the sardine processing plants and those plants which produce such products as fishsticks, breaded fillets, etc.

REFERENCES

1. A.P.H.A., W.P.C.F., Standard Methods for the Examination of Water and Waste Water, 13th edition, 1970.

2. Claggett, F. G., Fisheries Research Board of Canada, Vancouver Laboratory, Vancouver, B.c.

3. Montreal Engineering Company. Limited, Maritime Provinces Water Resources Study - Stage 1. Appendix III Industrial Water Demands Report prepared for Atlantic Development Board, 1969.

APPENDIX 1

Raw Data

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — GROUNDFISH FILLETING

DATE		JULY 13	JULY 13	JULY 13	JULY 13	JULY 14†	JULY 14†
STREAM		6	7	6	7	6	6
SAMPLING TIMES		08:30 11:30	08:30 11:30	13:00 16:00	13:00 16:00	08:30 11:30	13:00 16:30
BOD_5	mg/l	800	300	500	100	380	410
COD	mg/l	2500	1640	700	360	680	784
TVS	mg/l	3320	928	3200	3800	3700	3700
SS	mg/l	69	228	127	165	133	147
OIL	%	0.01	0.01	0.01	0.02	0.01	0.05
WATER USED IMP. GAL	FRESH						
	SALT						
	COMBINED	21112	5032	20442	4402	18512	22104
$\frac{BOD_5}{COD}$		0.32	0.18	0.71	0.28	0.56	0.52
PRODUCTION lbs.	LANDED L	106000 (assumed)				147830	
	PRODUCED P	32049				44349	
HOURS OF PRODUCTION		8				8	
$\frac{P}{L}$		0.30				0.30	

† OCEAN PERCH ONLY — NO WASTE STREAM 7

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — GROUNDFISH FILLETING

DATE		JULY 15	JULY 15	JULY 15	JULY 15	JULY 19	JULY 19
STREAM		6	7	6	7	6	7
SAMPLING TIMES		08:30 11:30	08:30 11:30	13:00 16:15	13:00 16:15	08:30 11:30	08:30 11:30
BOD_5 mg/l		380	500	430	1106	790	440
COD mg/l		960	800	553	1550	1100	760
TVS mg/l		926	756	5168	1220	2320	814
SS mg/l		42	164	261	232	164	44
OIL %		0	0	0	0.01	0.03	0.02
WATER USED IMP. GAL	FRESH						
	SALT						
	COMBINED	19765	3998	19767	3931	21205	5032
$\frac{BOD_5}{COD}$		0.40	0.63	0.78	0.71	0.72	0.58
PRODUCTION lbs.	LANDED L	116700 (assumed)				124300 (assumed)	
	PRODUCED P	35372				37297	
HOURS OF PRODUCTION		8				8	
$\frac{P}{L}$		0.30				0.3	

FISH PROCESSING
WASTE SURVEY DATA

PROCESS —— LOBSTER

DATE		JUNE 23	JUNE 23	JUNE 25	JUNE 28	JULY 2
STREAM		1	1	1	1	1
SAMPLING TIMES		08:30 11:45	13:00 14:00	08:15 10:30	09:00 11:00	08:15 09:00
BOD_5	mg/l	916	990	1084	843	1205
COD	mg/l	1712	2293	2180	1680	2500
TVS	mg/l	226	440	550	498	1100
SS	mg/l	141	174	171	170	162
OIL	%	0.08	0.06	0.01	0.01	0.01
WATER USED IMP. GAL.	FRESH					
	SALT					
	COM-BINED	8760	5840	7305	5391	2920
$\frac{BOD_5}{COD}$		0.54	0.43	0.50	0.50	0.48
PRODUCTION lbs.	LANDED L	5561		2279	2730	1200
	PRODUCED P	1682		729	722	233
HOURS OF PRODUCTION		5		2.5	3	1
$\frac{P}{L}$		0.3		0.32	0.26	0.19

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — CRAB

DATE		JUNE 24	JUNE 24	JULY 5	JULY 5	JULY 6	JULY 6
STREAM		4	4	5	5	5	5
SAMPLING TIMES		08:30 11:45	13:00 16:00	09:00 11:30	13:00 16:30	08:30 11:45	13:00 16:00
BOD_5	mg/l	976	1000	843	840	320	640
COD	mg/l	2160	2820	2600	2960	2960	1380
TVS	mg/l	690	987	3200	3217	3635	2380
SS	mg/l	244	661	309	313	285	223
OIL	%	0.02	0.01	0.01	0.01	0.09	0.09
WATER USED IMP. GAL	FRESH	7889	7560	5508	7344	7344	6408
	SALT	44829	45276	43200	57600	57600	45600
	COMBINED						
$\frac{BOD_5}{COD}$		0.45	0.35	0.32	0.28	0.11	0.46
PRODUCTION lbs	LANDED L	17576		22000		16500	
	PRODUCED P	4394		4600		3600	
HOURS OF PRODUCTION		7.5		8		8	
$\frac{P}{L}$		0.25		0.21		0.22	

FISH PROCESSING
WASTE SURVEY DATA

PROCESS —— CRAB

DATE		JULY 7	JULY 8	JULY 9	JULY 9	
STREAM		5	5	5	5	
SAMPLING TIMES		08:30 11:30	13:00 16:00	08:30 11:30	13:00 16:00	
BOD_5 mg/l		600	600	340	600	
COD mg/l		2920	3040	820	1640	
TVS mg/l		3130	5400	6160	4000	
SS mg/l		445	227	170	135	
OIL %		0.06	0.01	0.01	0.01	
WATER USED IMP. GAL.	FRESH	7344	7344	7344	6426	
	SALT	57600	57600	57600	50400	
	COM-BINED					
$\frac{BOD_5}{COD}$		0.21	0.20	0.41	0.37	
PRODUC-TION lbs	LANDED L	17300	22000	18000		
	PRO-DUCED P	4000	4800	3850		
HOURS OF PRODUCTION		8	8	8		
$\frac{P}{L}$		0.23	0.22	0.21		

FISH PROCESSING

WASTE SURVEY DATA

PROCESS —— COMBINED PROCESSING
GROUNDFISH & CRAB

DATE		JUNE 22	JUNE 22	JUNE 25	JUNE 29	JUNE 29
STREAM		3	3	3	3	3
SAMPLING TIMES		10:00 11:45	13:15 15:30	13:00 15:45	08:30 11:45	13:00 16:45
BOD_5	mg/l	1110	1230	1440	1090	1100
COD	mg/l	2613	2990	2600	2880	2900
TVS	mg/l	355	5497	530	349	999
SS	mg/l	320	330	174	324	338
OIL	%	0.04	0.02	0.02	0.10	0.07
WATER USED IMP. GAL.	FRESH	4776	5961	7200	9600	9600
	SALT	32130	36990	48818	63994	63994
	COM-BINED					
$\frac{BOD_5}{COD}$		0.42	0.41	0.55	0.38	0.38
PRODUCTION lbs.	LANDED L	51526		93303	113469	
	PRODUCED P	14736		27162	31689	
HOURS OF PRODUCTION		5.5		8.5	8	
$\frac{P}{L}$		0.29		0.29	0.28	

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — HERRING FILLETING

DATE		JULY 21	JULY 22	JULY 22	JULY 23	JULY 23
STREAM		8	8	8	8	8
SAMPLING TIMES		14:00 16:30	09:00 11:30	13:00 16:00	08:30 11:30	13:00 16:00
BOD_5	mg/l	3075	3750	5800	3200	3469
COD	mg/l	6320	4880	8640	5600	5280
TVS	mg/l	12016	2600	2488	6226	4484
SS	mg/l	5310	1150	2470	3455	2580
OIL	%	0.02	0.1	0.1	0.1	0.1
WATER USED IMP. GAL.	FRESH					
	SALT					
	COM-BINED	15948	16393	18981	20588	18115
$\frac{BOD_5}{COD}$		0.49	0.77	0.67	0.57	0.66
PRODUCTION lbs.	LANDED L	2900	72000		96640	
	PRODUCED P	10406	21298		34812	
HOURS OF PRODUCTION		4	8		8	
$\frac{P}{L}$		0.36	0.30		0.36	

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — MARINATED HERRING

DATE		JULY 20	JULY 20	JULY 21	JULY 27	JULY 30
STREAM		9	9	9	9	9
SAMPLING TIMES		08:30 11:30	13:00 14:30	08:30 11:30	14:30 16:00	08:30 16:00
BOD_5	mg/l	6900	7400	7900	8200	1400
COD	mg/l	10870	10400	9800	15400	19400
TVS	mg/l	4020	3600	1600	5420	5302
SS	mg/l	3920	1508	4600	2800	4224
OIL	%	0.2	0.2	0.08	0.5	broken bottle
WATER USED IMP. GAL.	FRESH	72491	43467	81880	61102	102255
	SALT					
	COM-BINED					
$\frac{BOD_5}{COD}$		0.63	0.71	0.81	0.53	0.72
PRODUCTION lbs.	LANDED L	45000		97660	38800	76100
	PRODUCED P	16650		38025	15300	37380
HOURS OF PRODUCTION		6		8	4.5	8
$\frac{P}{L}$		0.37		0.39	0.39	0.49

FISH PROCESSING

WASTE SURVEY DATA

PROCESS —— FISH MEAL
PUMP OUT WATER

DATE	AUG. 31	AUG. 31			
STREAM	16	16			
SAMPLING TIMES					
BOD_5 mg/l	13000	54000			
COD mg/l	36000	84000			
TVS mg/l	17230	93400			
SS mg/l	7250	8660			
OIL %	0.04	0.05			
$\frac{BOD_5}{COD}$	0.36	0.64			

FISH PROCESSING

WASTE SURVEY DATA

PROCESS — FISH MEAL
BLOOD WATER

DATE	AUG. 7	AUG. 9	AUG. 31	AUG. 31	
STREAM	15	15	15	15	
SAMPLING TIMES	08:30 13:00	08:30 16:00			
BOD_5 mg/l	315000	245000	190000	230000	
COD mg/l	472000	344000	336000	376000	
TVS mg/l	24000	22000	212290	157600	
SS mg/l	4168	5500	21430	16120	
OIL %	0.30	N. A.	0.27	0.25	
$\frac{BOD_5}{COD}$	0.67	0.71	0.57	0.62	

FISH PROCESSING

WASTE SURVEY DATA

PROCESS —— FISH MEAL
SEPARATOR SLUDGE

DATE	JULY 29	AUG. 2	AUG. 26		
STREAM	10	10	10		
SAMPLING TIMES	08:00 16:30	10:00 14:30			
BOD_5 mg/l	320000		210000		
COD mg/l	564000	664000	354600		
TVS mg/l		326200	155000		
SS mg/l		12300	14000		
OIL %	0.27	0.25	0.15		
$\frac{BOD_5}{COD}$	0.57		0.59		

FISH PROCESSING

WASTE SURVEY DATA

PROCESS — FISH MEAL STICKWATER

DATE	JULY 29	AUG. 2	AUG. 26		
STREAM	11	11	11		
SAMPLING TIMES	08:30 16:30	10:00 14:30			
BOD_5 mg/l	490000	60000	46000		
COD mg/l	600000	173300	64000		
TVS mg/l		47460	83800		
SS mg/l	17400	21500	7600		
OIL %	0.05	0.02	0.01		
$\frac{BOD_5}{COD}$	0.82	0.35	0.72		

FISH PROCESSING
WASTE SURVEY DATA

PROCESS —— FISH MEAL SOLUBLES

DATE	AUG. 2	AUG. 3	AUG. 4	AUG. 5	
STREAM	14	14	14	14	
SAMPLING TIMES	10:00 14:30	08:15 16:00	08:30 16:30	08:30 16:00	
BOD_5 mg/l	170000	150000	172000	245000	
COD mg/l	308000	272000	292000	560000	
TVS mg/l	4200	210000	352600	343800	
SS mg/l	1400	78500	85500	1050	
OIL %	0.2	0.02	0.1	0.2	
$\frac{BOD_5}{COD}$	0.55	0.55	0.59	0.44	

FISH PROCESSING

WASTE SURVEY DATA

PROCESS — FISH MEAL EVAPORATOR WATER

DATE	AUG. 3	AUG. 4	AUG. 5	AUG. 7	AUG. 9
STREAM	13	13	13	13	13
SAMPLING TIMES	08:15 16:00	08:30 16:30	08:30 16:00	08:30 13:00	08:30 16:00
BOD_5 mg/l	880	1180	949	1549	1100
COD mg/l	1960	1432	2800	2300	2440
TVS mg/l	470	94	234	21	264
SS mg/l	220	4	4		4
OIL %	0.03	0	0.01	0	0.01
$\frac{BOD_5}{COD}$	0.45	0.82	0.34	0.67	0.45

FISH PROCESSING
WASTE SURVEY DATA

PROCESS — FISH MEAL DEODORIZER WATER

DATE	AUG. 3	AUG. 4	AUG. 5	AUG. 7	AUG. 9
STREAM	12	12	12	12	12
SAMPLING TIMES	08:15 16:00	08:30 16:30	08:30 16:00	08:30 13:00	08:30 16:00
BOD mg/l	450	625	1349	1050	900
COD mg/l	1800	2753	2940	2340	2746
TVS mg/l	5790	6914	13260	5086	4742
SS mg/l	133	275	45	163	12
OIL %	0.01	0	0.01	0	0
$\frac{BOD_5}{COD}$	0.25	0.23	0.46	0.45	0.33

APPENDIX 2

Analysis of Data

PROCESS —— GROUNDFISH (DRY LINE)

DATE	lb. BOD_5/1000 lb		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.		
							COMBINED		
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD	LAND.	PROD.	
(6) JULY 12	1.0	3.0	0.42	1.2	0.88	2.6	879	2585	PERCH
(6,7) 13	2.9	10.0	0.59	2.0	0.54	1.8	514	1670	COD, FLOUNDER, PERCH
(6) 14	1.2	3.9	0.40	1.4	0.90	3.1	293	977	PERCH ONLY
(6,7) 15	1.9	6.3	0.65	2.1	0.03	0.11	407	1342	COD
(6,7) 19	3.1	10.1	0.60	2.0	1.2	4.0	426	1407	FLOUNDER
AVERAGE	5.1	6.7	0.53	1.7	0.71	23	504	1596	

( ) —— WASTE STREAM

PROCESS — GROUNDFISH (WET LINE)

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.			
							FRESH		SALT	
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.
JUNE 28 (2)	10	33	6	19	15	49	102	340	1537	5114
30 (2)	19	54	7	21	11	33	215	630	1110	3259
AVERAGE	15	44	7	20	13	41	159	485	1324	4187

( ) — WASTE STREAM

PROCESS —— LOBSTER

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.		
							COMBINED		
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	
JUNE 23 (1)	25	83	4	14	13	43	2625	8680	
25 (1)	26	109	4	17	2	10	2435	10021	
28 (1)	25	100	5	20	3	13	2960	11927	
JULY 2 (1)	29	150	4	22	3	13	2433	12352	
AVERAGE	26	110	4	18	5	20	2613	10745	

( ) —— WASTE STREAM

PROCESS —— CRAB PROCESSING

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.			
							FRESH		SALT	
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.
(5) JULY 5	50	240	18	88	6	28	668	3193	5236	25043
(5) 6	36	167	19	88	68	312	889	4075	6671	30578
(5) 7	27	117	20	87	27	117	511	2212	4011	17349
(5) 8	36	163	13	61	6	27	668	3060	5236	24000
(5) 9	33	156	15	68	8	36	816	3815	6400	29925
(4) JUNE 24	59	237	27	109	9	36	879	3516	5126	20506
AVERAGE	40	270	19	84	21	93	739	3312	5447	24567

( ) —— WASTE STREAM

PROCESS —— GROUNDFISH & CRAB

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.			
							FRESH		SALT	
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.
JUNE 22 (3)	18	63	5	17	5	16	188	656	1341	4691
25 (3)	24	83	3	10	3	12	197	676	1482	5092
29 (3)	13	48	4	15	12	41	152	545	1128	4039
AVERAGE	18	65	4	14	7	23	179	626	1317	4607

( ) —— WASTE STREAM

PROCESS —— HERRING FILLETING OPERATION

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.		
							COMBINED		
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	
JULY 21 (8)	22.5	62.8	38.9	108.5	14.7	40.9	733	2043	
22 (8)	29.3	99.1	11.2	38.0	6.1	20.5	605	2045	
23 (8)	15.2	42.3	13.9	38.7	8.9	24.6	458	1271	
AVERAGE	22.0	68.1	21.3	37.0	9.9	28.7	599	1786	

( ) —— WASTE STREAM

PROCESS —— MARINATED HERRING

DATE	lb. BOD_5/1000 lb.		lb. SS/1000 lb.		lb. OIL/1000 lb.		GALLONS H_2O/1000 lb.			
							FRESH		SALT	
	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.	LAND.	PROD.
JULY (9) 20	199	538	85	229	56	152	2811	7597	0	0
(9) 21	151	388	88	225	15	39	1914	4916	0	0
(9) 27	293	744	100	254	179	454	3579	9076	0	0
(9) 30	215	438	65	132	broken bottle	sample	1536	3126	0	0
AVERAGE	215	527	85	210	83	215	2460	6179		

( ) —— WASTE STREAM

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